servatory, at which every branch of investigation and study bearing on the atmosphere will be pursued, especially (1) observations of the upper strata of the air by means of kites and balloons, (2) observations of the clouds by the nephoscope, (3) experiments in the physical laboratory on the motions of small masses of air under conditions that are precisely known, (4) observations of the total radiation from the sun by means of actinometers and bolometers, (5) details of the solar condition recorded by apparatus at the solar physical observatory, (6) records of the electrical and magnetic phenomena of the earth and atmosphere, and (7) particularly the education of special students in the interpretation of all these observations by means of the higher mathematics, so that the results of the knowledge thus gained may advance meteorology and improve the weather forecasts.

This recognizes that behind every practical art of doing there must be a higher science of studying and knowing.

IMPORTANCE OF RESEARCH OBSERVATORIES FOR THE PROMOTION OF METEOROLOGY.

The public is familiar with the idea that it is a fine thing to establish great hospitals, universities, libraries, churches, technical schools, and other institutions that minister to the practical needs of mankind, but very few have as yet awakened to realize the fundamental importance of institutions for the increase of knowledge, as distinguished from those that merely diffuse knowledge or from many others that apply knowledge to ameliorate the condition of mankind. We often think of our public institutions as marking the great difference between the present and the past ages, but the ancients had their asylums and hospitals, their irrigation systems, their machinery, aqueducts, sewers, and other ways of applying whatever knowledge they had.

The fundamental difference between the present age and all previous time is not the school nor the asylum, but the enormous increase in our actual knowledge of nature in all her minutest and most complex workings. We must increase knowledge before we can teach it or apply it and to bring about this increase is the peculiar province of those men who devote themselves to research so-called. A few names distinguished for research come down to us from antiquity, such as Archimedes, Eratosthenes, Pliny, Aristotle. Doubtless there were others whose names have been forgotten, but in modern times the number has been immensely increased since the days of Copernicus, Galileo, Newton, Huyghens, and Descartes.

Science is sometimes said to be a systematic arrangement of our knowledge of nature as distinguished from the vague and erroneous traditions and guesses of less fortunate times; but modern science is more than an arrangement of knowledge—it is research for the purpose of increasing knowledge. No one can hold a high place in science unless it can be shown that he has on many occasions been able to elucidate with precision that which was previously imperfectly known or perhaps unsuspected. The best scientific men, or "researchers" as they have lately been called, are distinguished by an inborn and cultivated ability to concentrate their whole energies upon a solution of a definite problem until the work is done. Generally speaking they do not care so much for salaries or positions or the practical application of their knowledge, as they do for the opportunity of devoting their lives to the research work that they love. Such valuable men have to be provided for and for several centuries scientific societies and the better endowed universities as well as wealthy men have set aside small sums of money establishing fellowships or something equivalent for the support of those who have shown ability in research. In fact the German universities have for 90 years been animated more by the spirit of research than of instruction, and promotions therein have been based almost wholly on ability in original research.

There have been several notable illustrations of munificent foundations for the special benefit of research. Such was the Royal Institution of London organized about 1800 by that most brilliant American, Benjamin Thompson, Count Rumford. It has supported such eminent men as Sir Humphrey Davy, Michael Faraday, John Tyndall, and Lord Rayleigh.

Doubtless it was this successful foundation that led James Smithson to establish his great fund "for the increase and diffusion of knowledge" in which sentence he in fact quoted from Washington's farewell address. Possibly Smithson thought that in a free and peaceful republic scientific men would be less trammeled than in an aristocratic and warlike nation. He himself loved knowledge for its own sake but doubtless realized that to some "knowledge is wealth" to others "knowledge is power." Hitherto Americans like Peabody and Rockefeller have distinguished themselves by the endowment of education; Carnegie has given a great fund for research; Lick, Yerkes, McCormick, and others have given large sums for special research in astronomy, but we know of no one who has endowed research in meteorology. It has therefore become unavoidable that the Weather Bureau should solicit from the Federal Congress of the United States the funds needed for research in that difficult branch of science whose development is essential to the improvement of practical meteorology.

We quote the following appreciative remarks from an article by Dr. Frank Waldo, in the Boston Evening Transcript of August 19, 1905:

> Is there an honest and economical reason for this establishment? Being conversant with Weather Bureau conditions I am able to answer in the affirmative. It has been a long cherished desire on the part of all Government meteorologists to undertake the class of careful studies of the atmospheric conditions that have been pursued by some European governments. But a lack of proper facilities has, in a great measure, prevented such undertakings, their practical importance not being recognized by the "appropriating" powers who have been more interested in the matter of extending weather predictions to a wider circle of recipients, than in the slow increase of accuracy which might be expected to result from expensive studies and costly equipments. This feeling of economy went so far some years ago that the official publication of professional papers by the Weather Bureau was ordered discontinued. * * *
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> While great advances have been made in theoretical meteorology yet what has been most needed has been more accurate and more numerous observations of atmospheric conditions, not only over the world at large, but also in special locations. This last has necessitated the establishment of proper observatories.
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> Three kinds of special observatories have been erected in the prosecution of meteorological studies. First, a central observatory, which acts as a bureau institution for the ordinary observing stations such as are scattered over the country—whence the former may control the work of others and set them an example of the highest class of work in their line of observation. Such an observatory has been maintained at Washington from the beginning of our Weather Bureau, although its efficiency has greatly increased within recent years since the Bureau has had a building of its own. These observatories were mostly established in the capital cities.
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> But as the work of observational meteorology increased in accuracy, observatories were instituted at some distance from the disturbing influence of the towns. To this class belong the famous observatories of Kew, at Richmond, England, Pavlovsk in Russia, and Potsdam near Berlin. We had indeed one somewhat similar observatory in this country, Central Park, New York; but it was conducted on a meager scale and in its work did not attain the refinement of the great observatories of Europe. But we had no national observatory of that class.
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> As long ago as 1883 * * * the present writer was directed by Gen. W. B. Hazen, then the head of the Signal Service, to draw up plans for a small observatory of this class to be established at Fort Myer, Va., which was then the training school for the Signal Service men and was under control of that Service. By utilizing the temporary buildings already constructed at Fort Myer, only a few thousand dollars were needed for the proper housing and setting up the meteorological instruments. But even that petty sum was not forthcoming, chiefly owing to the objections in Congress.
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> Fort Myer has passed out of control of the Weather Bureau, and now twenty years after General Hazen's unsuccessful attempt Professor Moore has established such an observatory as the Weather Bureau has so long needed, only to be attacked by sensation mongers. What will these critics say when they are told that the best interests of practical meteorology require at least 25 such observatories located at different parts of the United States? The day will come when we shall have them. * * *
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> It is one of the anomalies of our educational system that weather

science which plays such an important part in our daily lives should be so little taught that in all our hundreds of colleges there is only one that has a chair of climatology. We are an agricultural nation and the variations in the weather are the chief cause of variations in crops—and yet the farmers' children are taught almost nothing about the science of *weather and climate and their relations to agriculture.* * * *

The exquisitely appointed Russian observatory at Pavlovsk is located in a corner of a park belonging to the royal family. There the late Professor Wild was accustomed to spend his summers and while he no doubt enjoyed its beauties, yet he carried on experiments and observations which made this observatory the most celebrated of its kind in the world. The present writer will never forget the summer weeks that he spent in that fairyland of science.

Or take another case, that of the Potsdam Observatory. The German Government is not given to wasting money and yet it supports a most extensive observatory in the beautiful Potsdam Park; an observatory which performs in part the same functions as will the new Weather Bureau observatory.

A third kind of observatory has also been established in Europe, viz, well equipped observatories at high elevations on mountain peaks. Such are the observatories of Ben Nevis, Scotland, Puy de Dome and Pic du Midi in France, and the Sonnblick in the Tyrol. We had it is true our own Mount Washington and Pikes Peak government observatories, but they were only counterparts of the ordinary Signal Service observing stations and had none of the completeness of the best European mountain observatories. *It remained for Mr. A. Lawrence Rotch, of Boston,* to give us the first well-equipped mountain observatory in this country, and although he located it on the relatively low-lying crest of the great Blue Hill, yet it is perfect in its appointments, and sets us an example by which to build our future mountain observatories. The work of this private observatory is among the best of its kind in the world.

However pleasant a few days sojourn on a mountain top may be in midsummer, no one will say that it remains agreeable for any lengthy stay, and a winter's residence is only made bearable by a sense of obligation or duty. Some of the most heroic scientific work ever undertaken has been at these mountain meteorological stations, as the records of Ben Nevis, the Sonnblick, and Mount Washington amply show. And the new Mount Weather Observatory will undoubtedly furnish an additional field for heroic winter scientific research, although the climate is not so severe as on some higher mountains on which observatories have been located.

That observatory is in a manner a combination of these two kinds of observatories, in both of which our Government service has hitherto been lacking; it fills the place of two observatories by accomplishing the work of both. It has then been an economy to build this combination observatory. * * *

At the present time the Weather Bureau has no adequate training school for its observers, and its new observatory will fill this need to the extent of its limited capacity. * * *

There are many college instructors and other scientific men who desire to carry on some special work, bearing on meteorology, at a well equipped observatory. Such men are made welcome at the great European observatories, and they have carried on valuable observations and experiments. The Weather Bureau is now for the first time able to extend such courtesies to American and foreign scientists. * * *

There is a great class of refined observations which can only be carried on at a distance from the disturbing influence of a city. Such observations can now be undertaken at this new observatory. In the study of the phenomena connected with American storms it has an unsurpassed location. It lies as nearly as possible within the track of the three great classes of storms that sweep over the eastern United States; the cyclones from the Mississippi Valley, those from the west Gulf (Texas and Mexico), and those from the West Indies which pass along our eastern coast. We may now expect that much light will be thrown upon the relations of these storms. * * *

In fine, the building of this new weather observatory must be regarded as the most important step taken by our Government in late years for the betterment of the Weather Bureau service.

MOUNTAIN STATIONS AND THEIR IMPORTANCE.

A letter of March 23, 1905, from Prof. Alexander G. McAdie incloses one from Prof. J. E. Church, jr., of the Nevada State University, Reno, Nev., relative to observations on Mount Whitney, Cal., and Mount Rose, Nev., with the request that the Editor give his opinion as to the importance of mountain stations.

The letter of Professor Church reads as follows:

RENO, NEV., *March 18, 1905.*

Prof. ALEXANDER MCADIE,
San Francisco, Cal.

DEAR SIR: Mr. Marsh and I spent eight days on Mount Whitney and climbed to the altitude of 13,250 feet where we could look down on Langley's Lake. At this point the ledge was piled full of drifting snow with a treacherous crust beneath, I now believe that we could have succeeded in crossing this, although the risk would have been great.

The ascent to 13,500 could be made at any season of the year, I believe, especially if two or three cabins were constructed along the trail for refuge in case of storm. Access could be had to the summit also during most of the year, Mr. Marsh believes, if a narrow trail for man were cut higher up the pinnacles where the drift snow could not lodge in sufficient quantity to prevent the observer from keeping the trail open. The expense would not exceed $150.

The weather was mild, though snow clouds hung over the mountains. The temperature did not fall below 10° F. The wind blew almost constantly from the east, from the subtropical Owen's Valley, and seemed to have an appreciable affect upon the temperature of the mountain, for Lone Pine Lake (9800 feet) and Mirror Lake at timber line (10,450 feet) were only partially frozen over, while the lakes west of Mount Whitney at apparently similar altitudes were frozen completely over and covered with snow. The snow also was mealy and unstable, with little hardness anywhere, such as I have always found on Mount Rose above the altitude of 8500 feet.

As regards the difficulty of the ascent in winter, I should consider Mount Shasta as not only far easier, but also entirely safe save for the possible fusillade of rocks below the Red Cliffs. There is no horse trail up Mount Shasta, however, above the altitude of 9000 feet.

I wish I were free to volunteer to take observations on Mount Whitney for you for a year.

If you are willing, I will take the readings of a maximum and minimum thermometer on Mount Rose (10,860 feet) north of Lake Tahoe, nearly every month during the coming twelve months, if you will send me the instruments. The results might have some value. Mount Rose is the highest point east of the summits of the Sierras and north of Lake Tahoe. The wind is usually very high there, but Lake Tahoe may have an influence on the temperature. If you are favorable, I could place the thermometers on Mount Rose at once. The temperature early in February at 6500 feet altitude on this mountain fell considerably below zero to judge from the frost crystals in my sleeping bag and frosted feet, and from the temperature of —15° and —25° F. at Truckee and Floriston the same night.

Our party had the honor of naming the peak directly south of Lone Pine Pass, Mount McAdie, to commemorate your services in advancing the science of climatology. Its altitude is at least 13,500 feet. If, as Mr. Marsh declares, this peak has not previously been named, we beg that you allow this name to stand.

The importance of mountain stations has been felt to an increasing degree ever since Perrier, by the advice of Pascal and Descartes, ascended the Puy de Dome, and demonstrated beyond all cavil that barometric pressure diminishes with altitude in proportion to the weight of the atmosphere left below as the observer ascends. It thus became evident that the vacuous space in the upper part of the barometer tube was not due to the fact that nature abhors a vacuum, but to the actual pressure exerted upon the mercury in the cistern by the surrounding gas. The so-called barometric constant now used in hypsometry was approximately determined about 1800–1810 by a series of observations made by Ramond at the summit of the Pic du Midi de Bigorre, France, and by Dangos at Tarbes near the base of that mountain. But permanent mountain stations began at a much later period, and for a long time the most famous of these were our own stations on Mount Washington and Pikes Peak. As the Editor had something to do with the establishment and maintenance of these stations, he may be allowed to say that their records still rank among the most important that we have. They gave us, day by day, positive knowledge in place of hypotheses as to what was going on in the atmosphere far above the conditions depicted on our daily weather maps. It was not necessary to reduce such stations to sea level, for we wanted the records as they were for these upper levels. If we could only have had enough stations to make maps of the conditions above us, we should undoubtedly have advanced far ahead of where we are now in our knowledge of the atmosphere and in our ability to predict the weather. In future years numerous kite and balloon stations will undoubtedly enable us to realize this great desideratum.

Now that very high mountain stations exist all over the world, we may turn to them and the studies that have been made of their records, especially as quoted in Hann's Lehrbuch